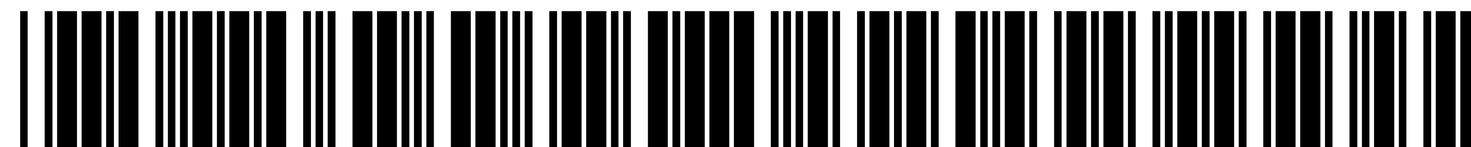

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Jeon

(10) **Patent No.:** **US 7,438,581 B1**
(45) **Date of Patent:** **Oct. 21, 2008**

(54) **SOCKET HAVING PRINTED CIRCUIT BOARD BODY PORTION**

(76) Inventor: **Myoungsoo Jeon**, 39422 Zacate Ave., Fremont, CA (US) 94539

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/433,099**

(22) Filed: **May 12, 2006**

Related U.S. Application Data

(60) Provisional application No. 60/681,675, filed on May 16, 2005.

(51) **Int. Cl.**
H01R 4/50 (2006.01)

(52) **U.S. Cl.** **439/342**; 439/101; 439/947

(58) **Field of Classification Search** 439/101, 439/108, 342, 947
See application file for complete search history.

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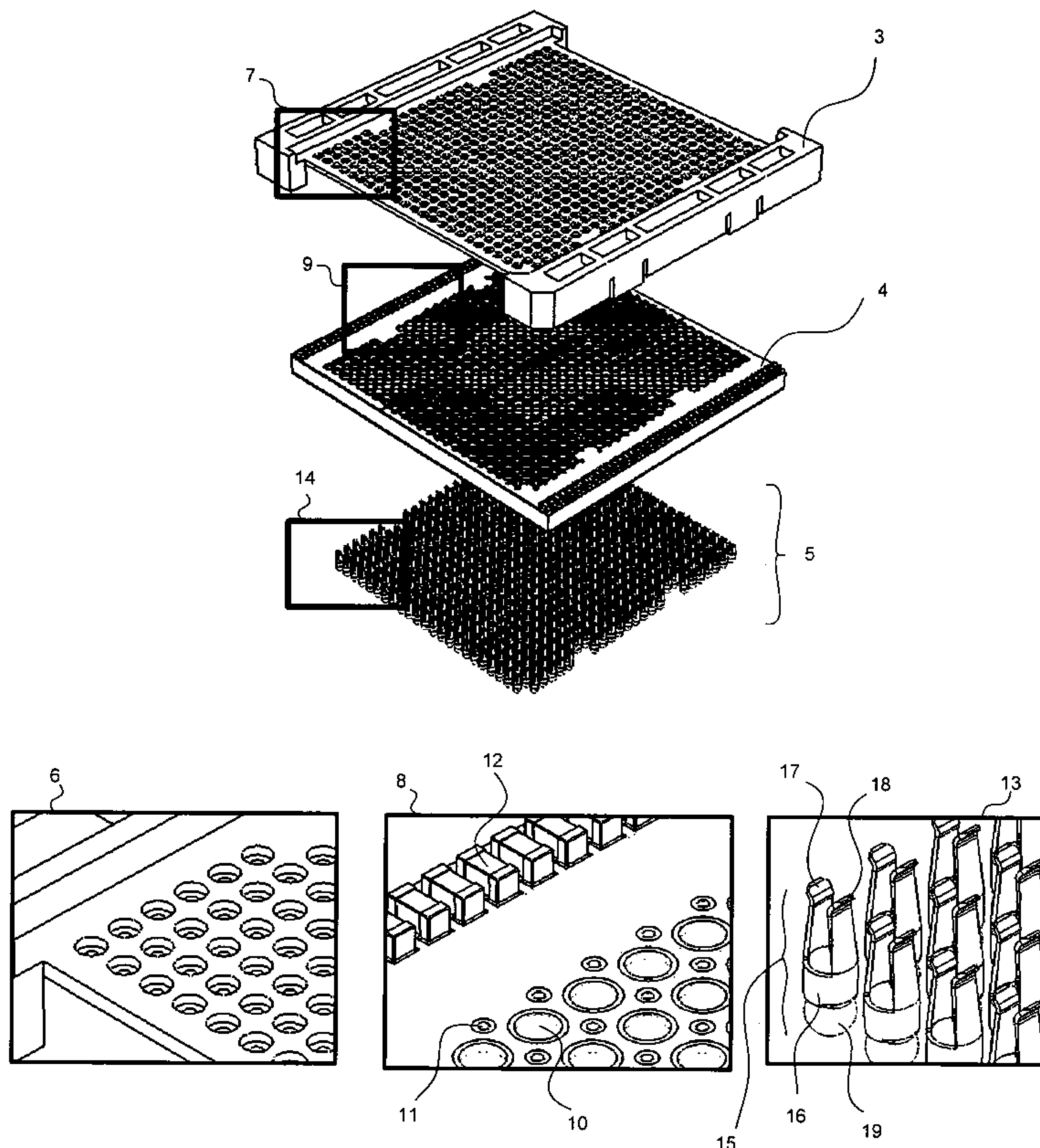
(74) *Attorney, Agent, or Firm*—Imperium Patent Works LLP; T. Lester Wallace; Zheng Jin

(57) **ABSTRACT**

A high speed socket includes an insulative housing and a printed circuit board body portion. The PCB body portion includes a PCB and surface mount contacts. Each surface mount contact has a first end portion for making contact with an integrated circuit held in the socket and a second end portion for surface mounting to a printed circuit board. The socket's printed circuit board includes AC grounded conductive columns (ACGCC) that extend from a first planar surface of the PCB to a second planar surface of the PCB. The printed circuit board also includes signal conductors. The signal conductors are shielded by the ACGCCs. In one aspect, the socket includes capacitors that are surface mounted to the socket's PCB. In another aspect, the surface mount contacts include self-adjusting solder tails that accommodate PCB warpage.

20 Claims, 19 Drawing Sheets



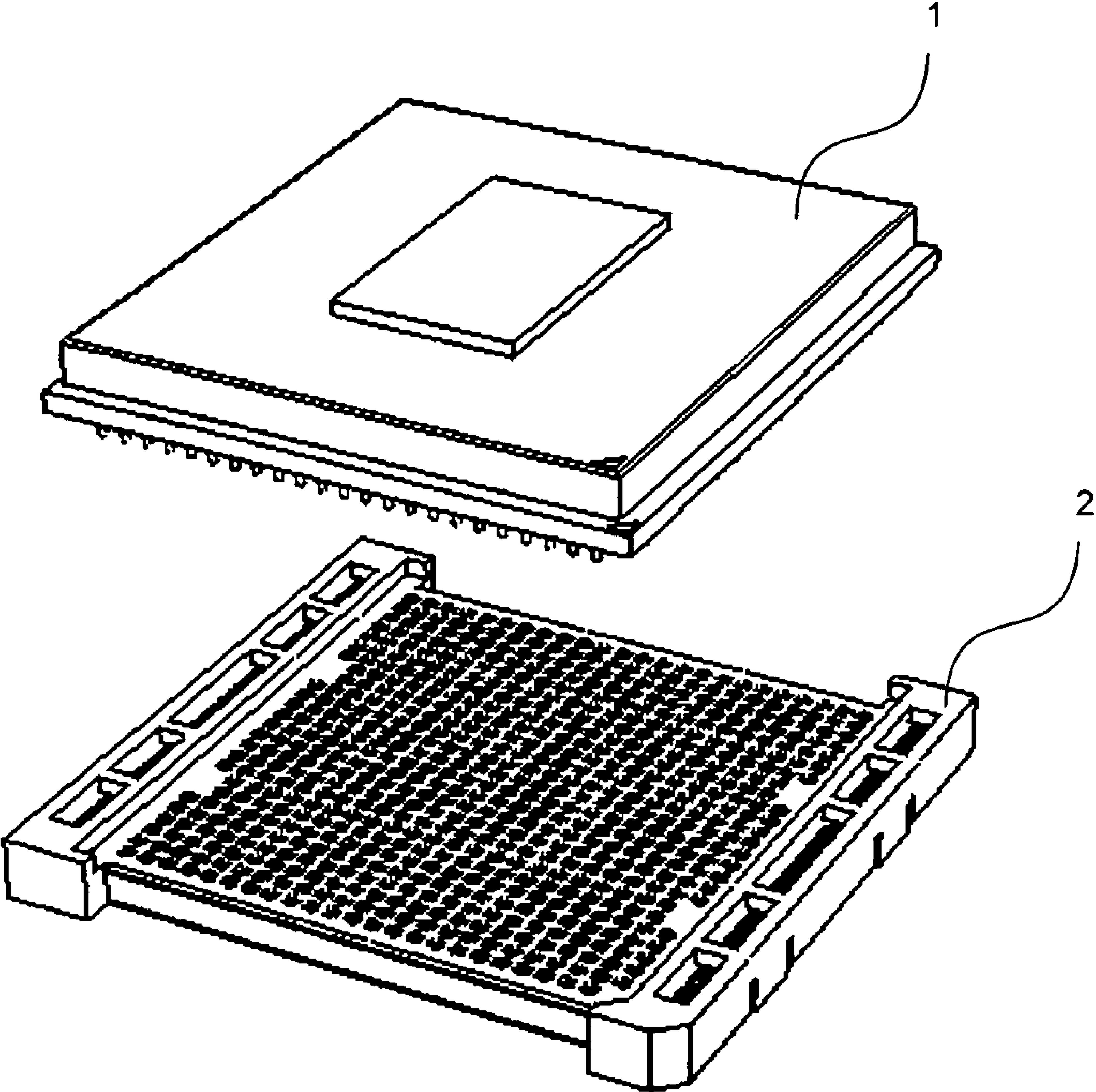


FIG. 1

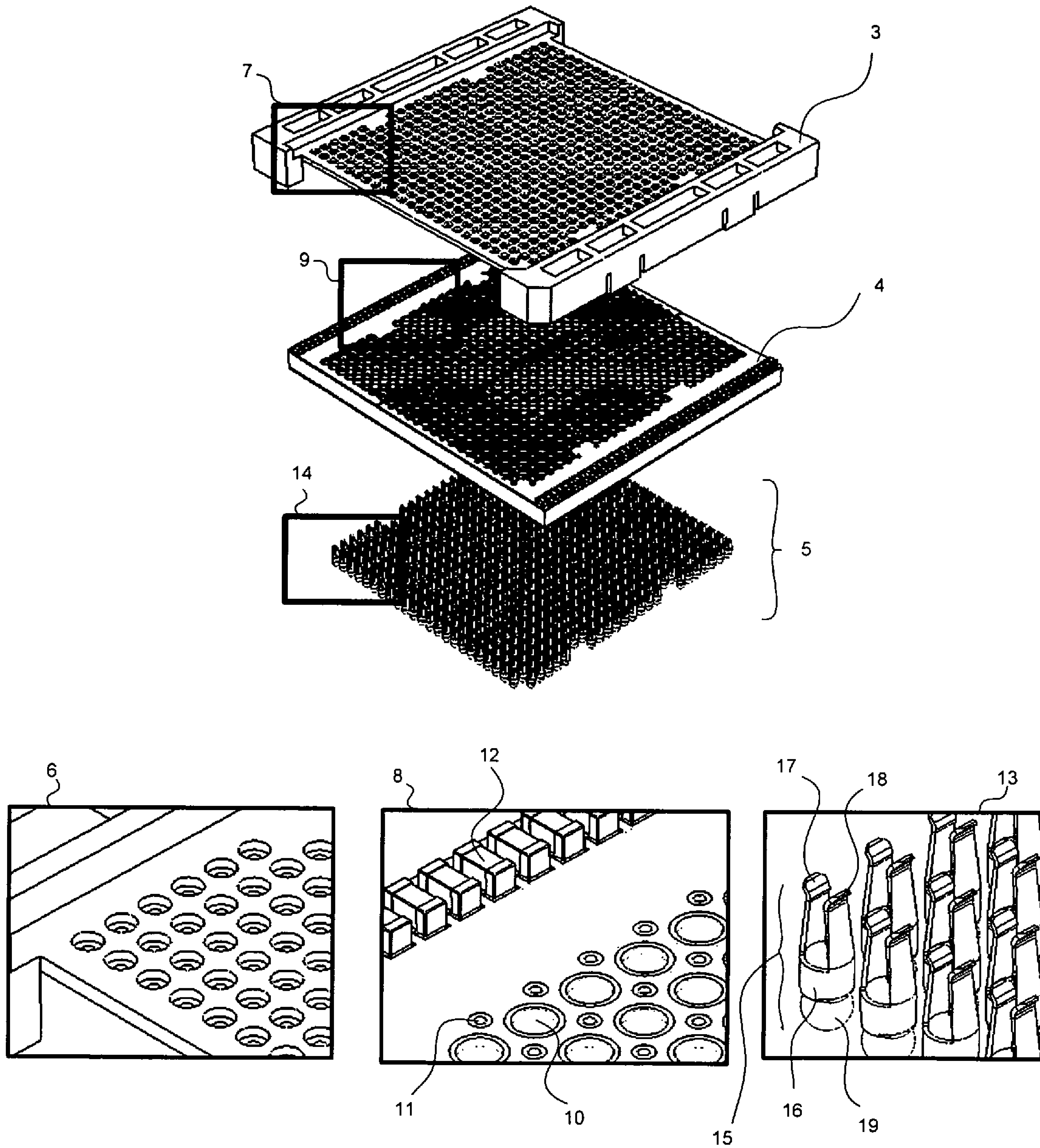


FIG. 2

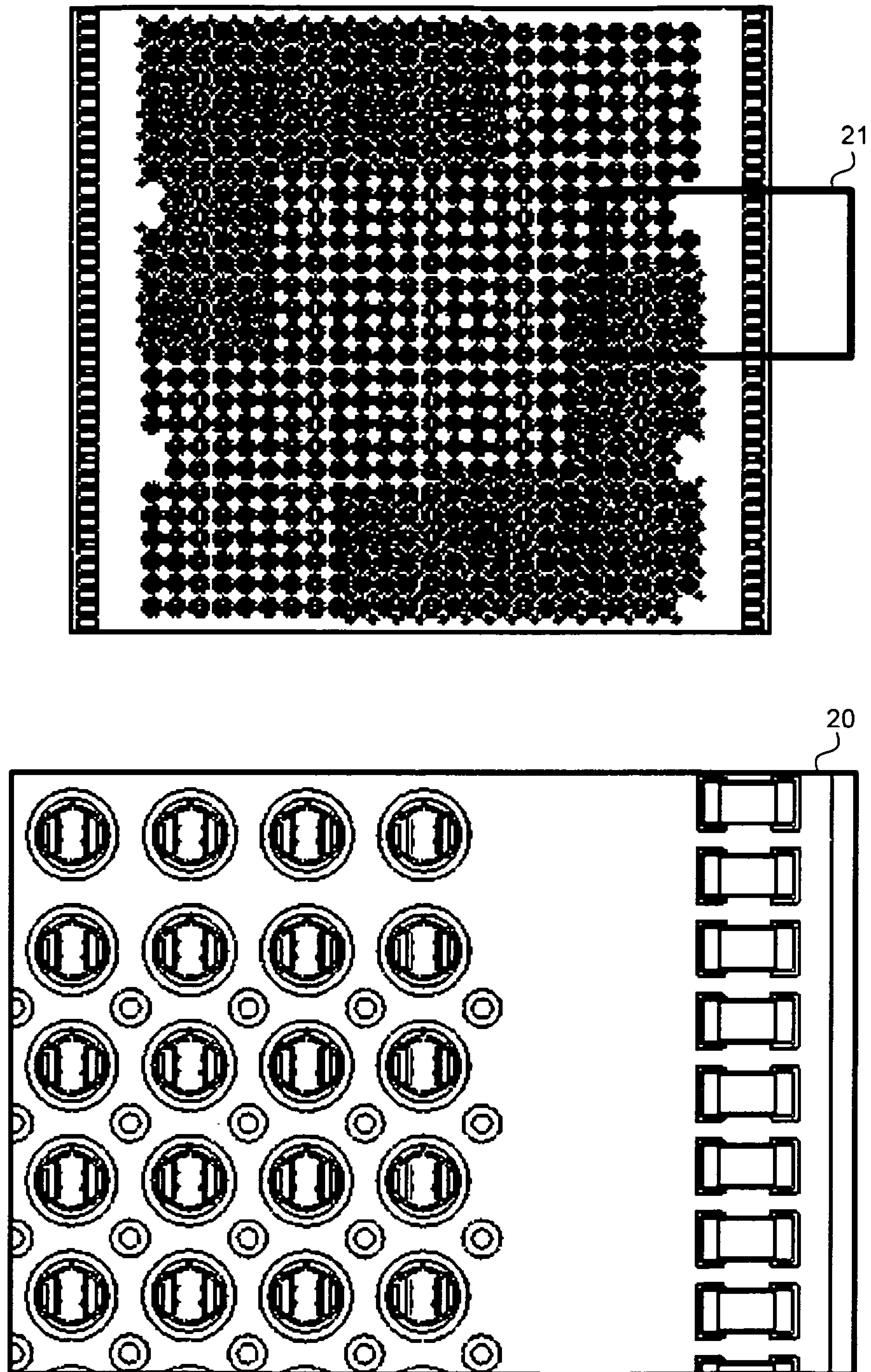


FIG. 3

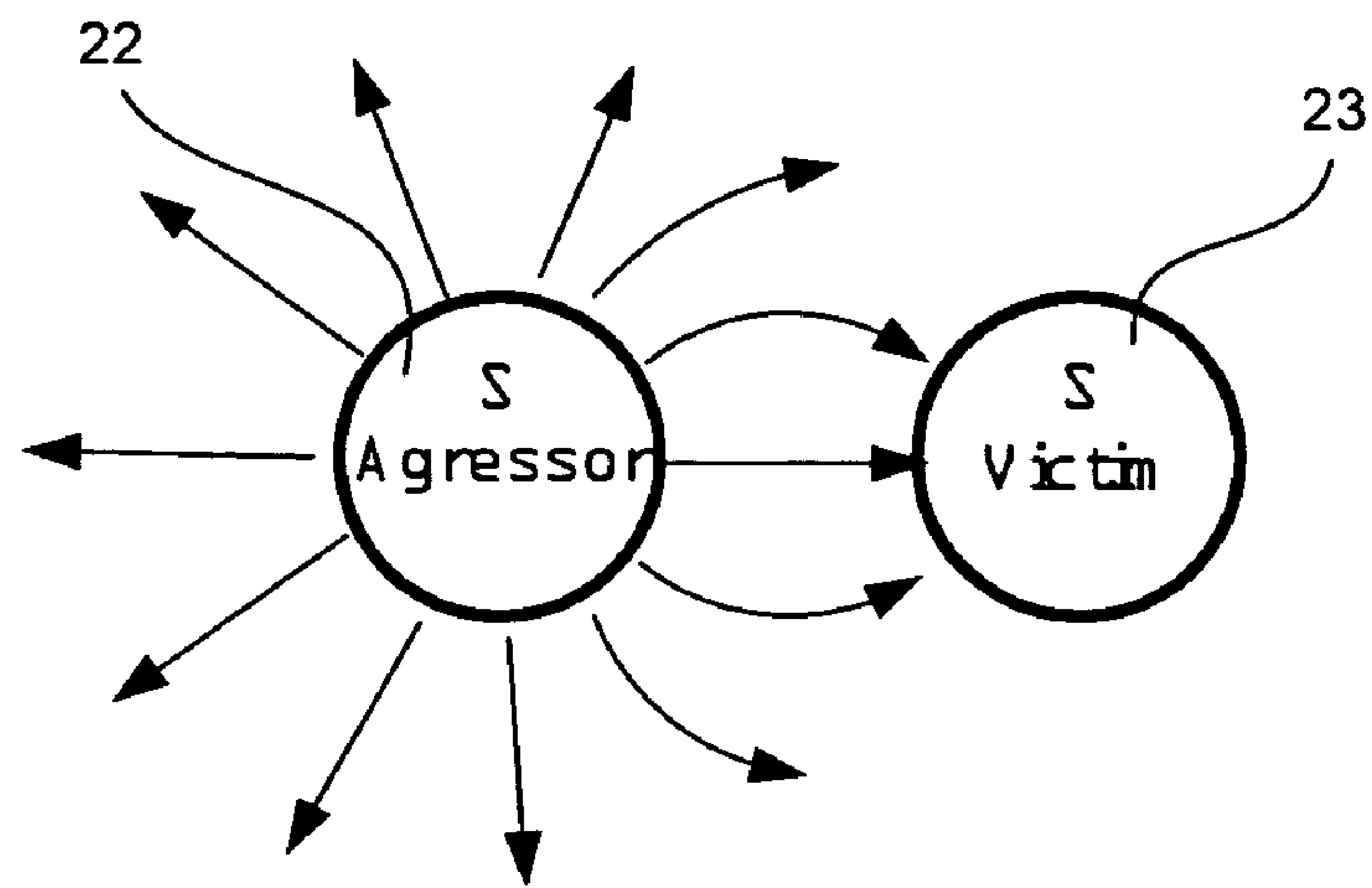


FIG. 4A

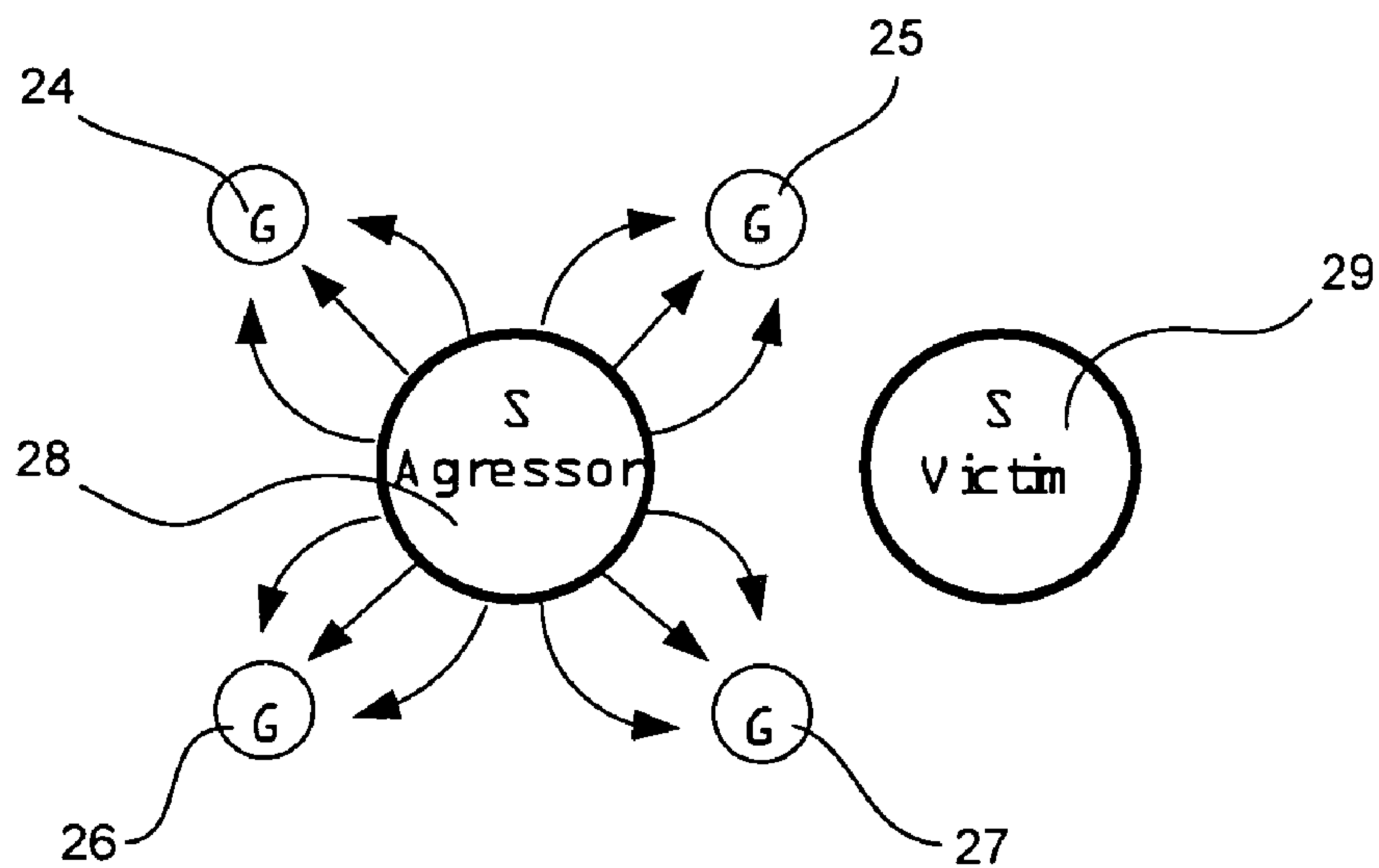


FIG. 4B

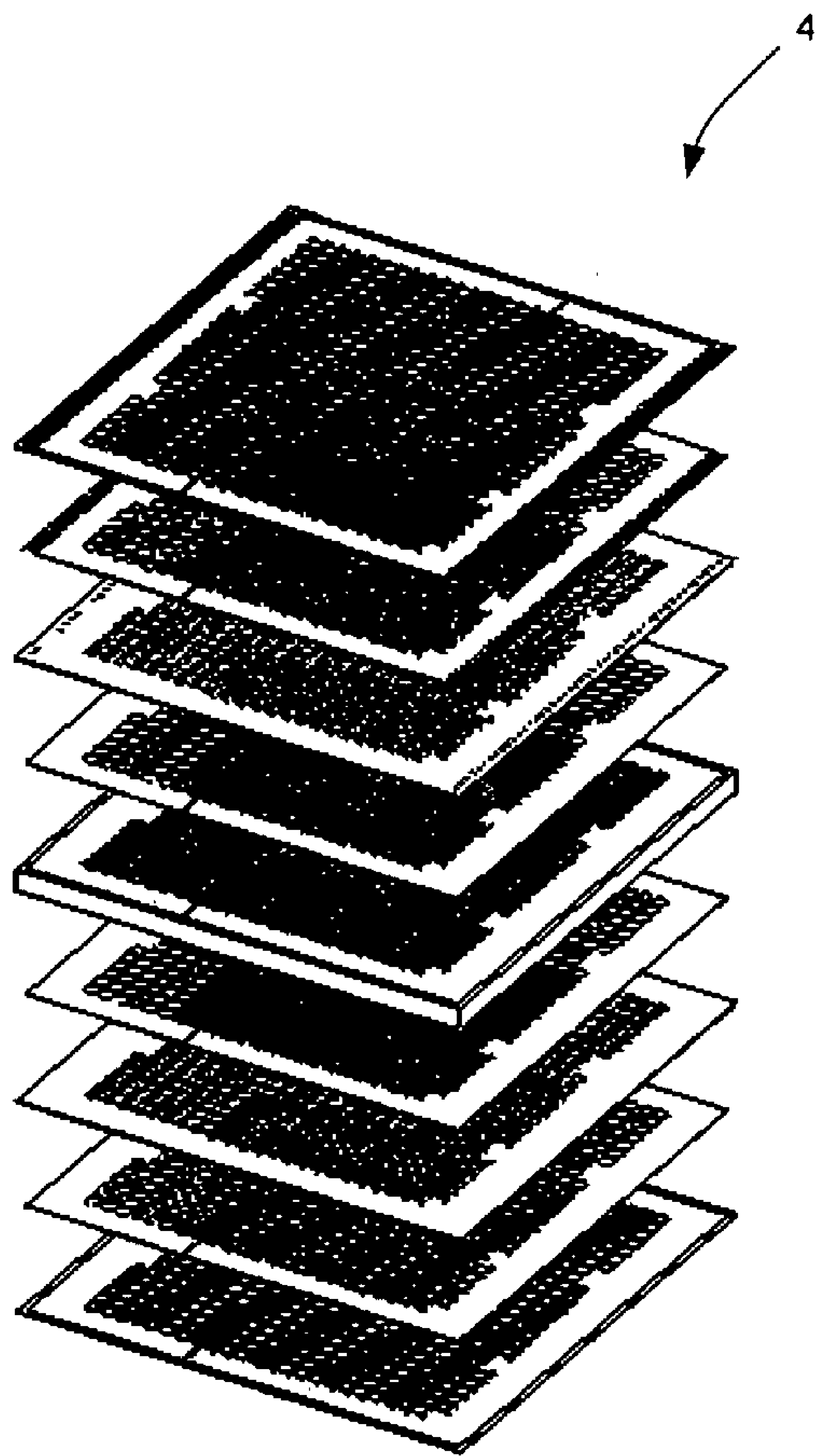


FIG. 5

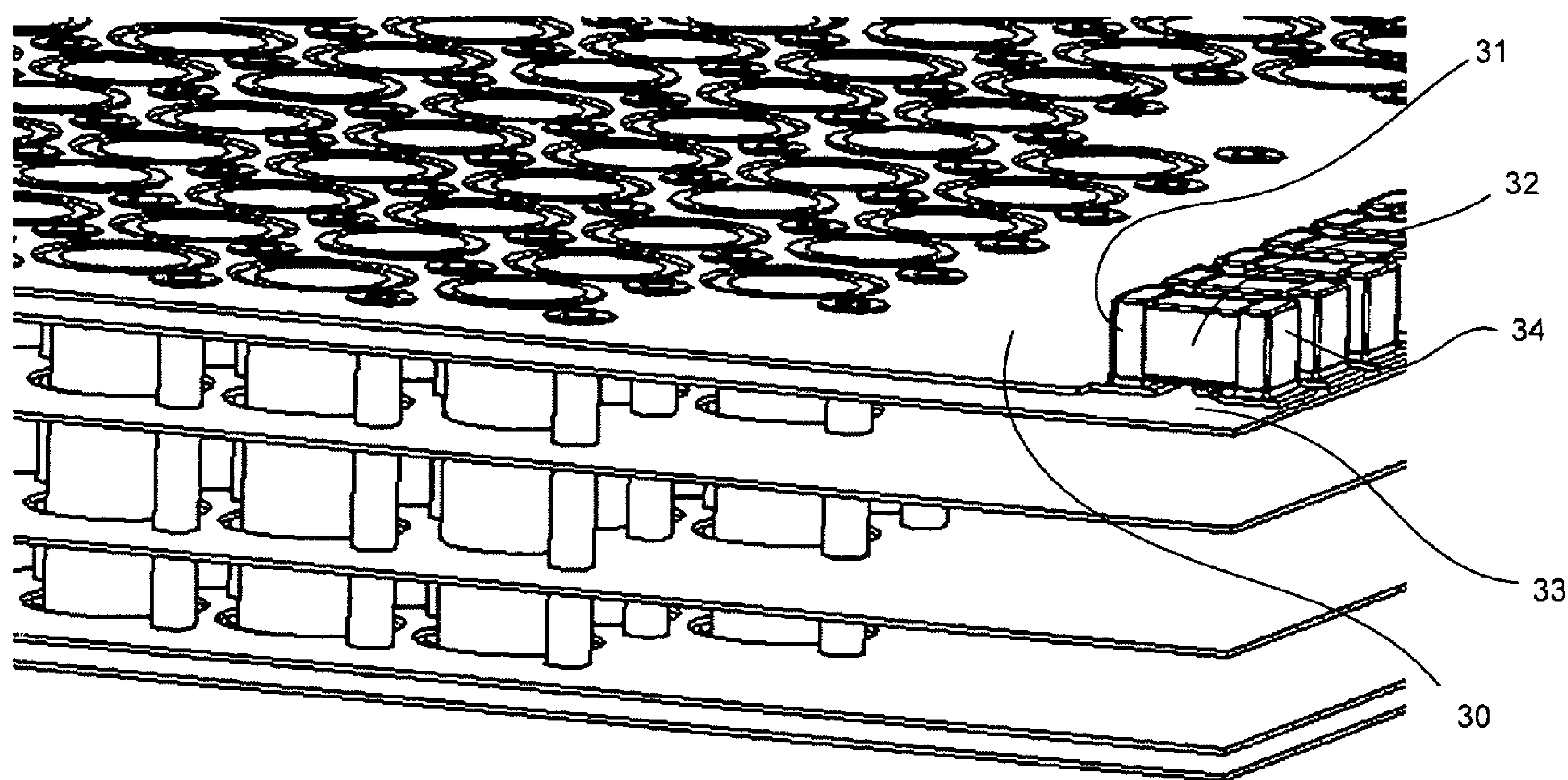


FIG. 6

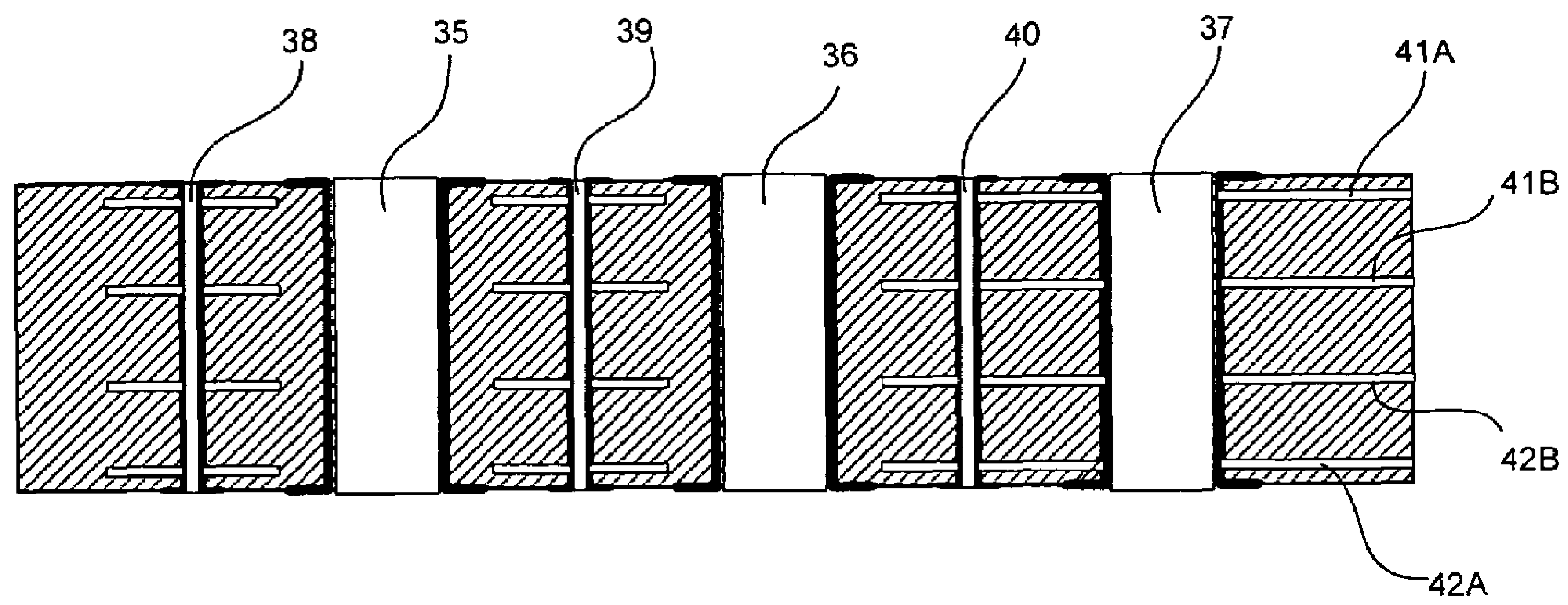


FIG. 7A

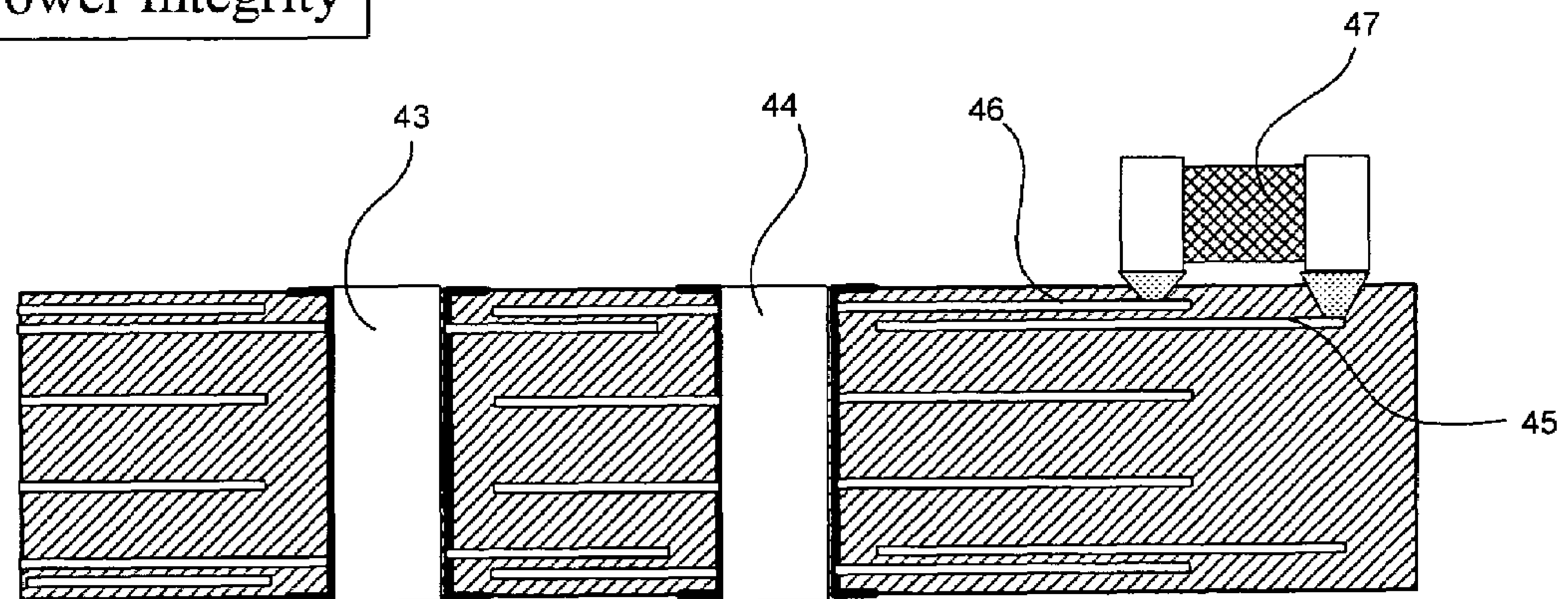


FIG. 7B

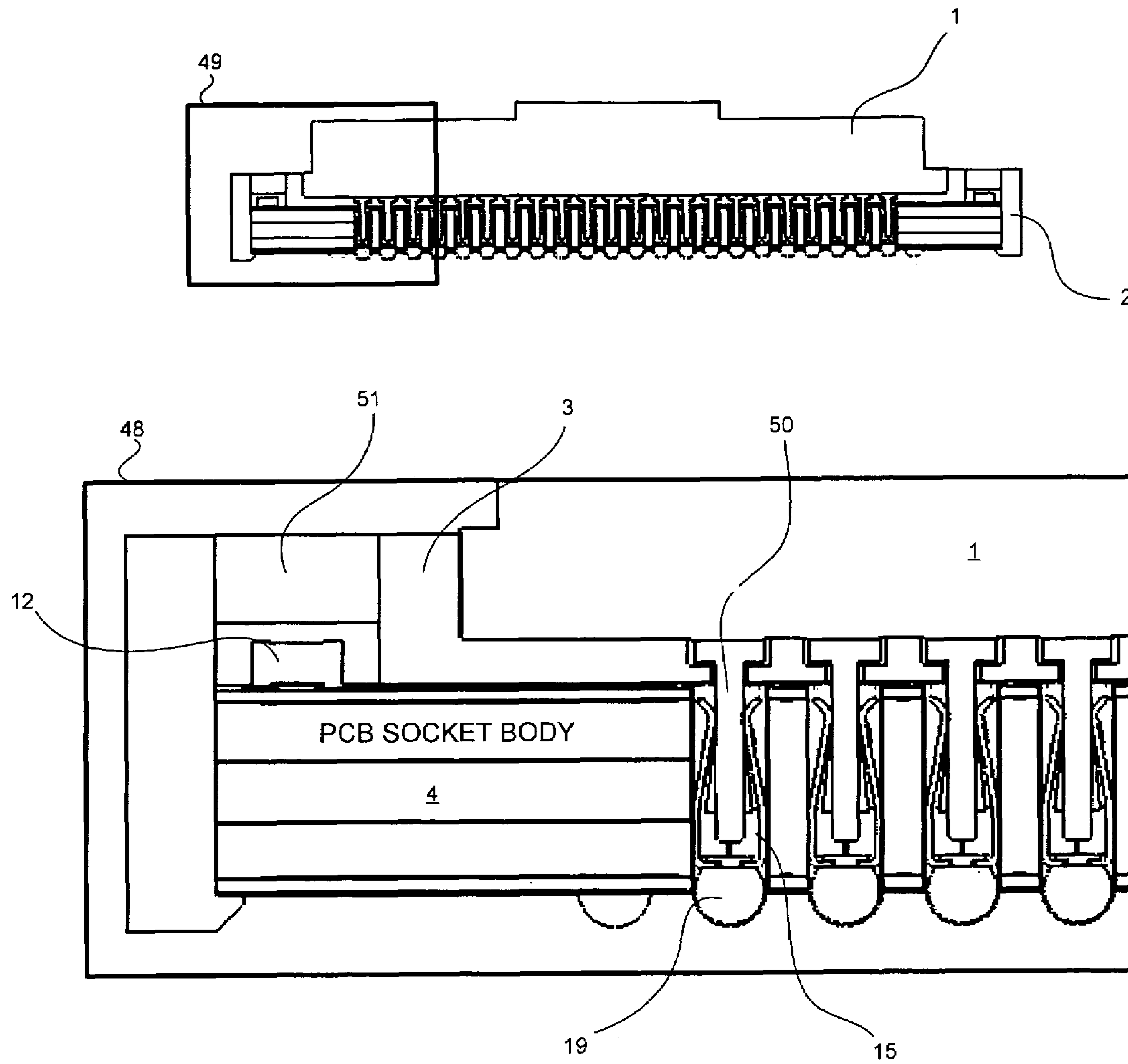


FIG. 8

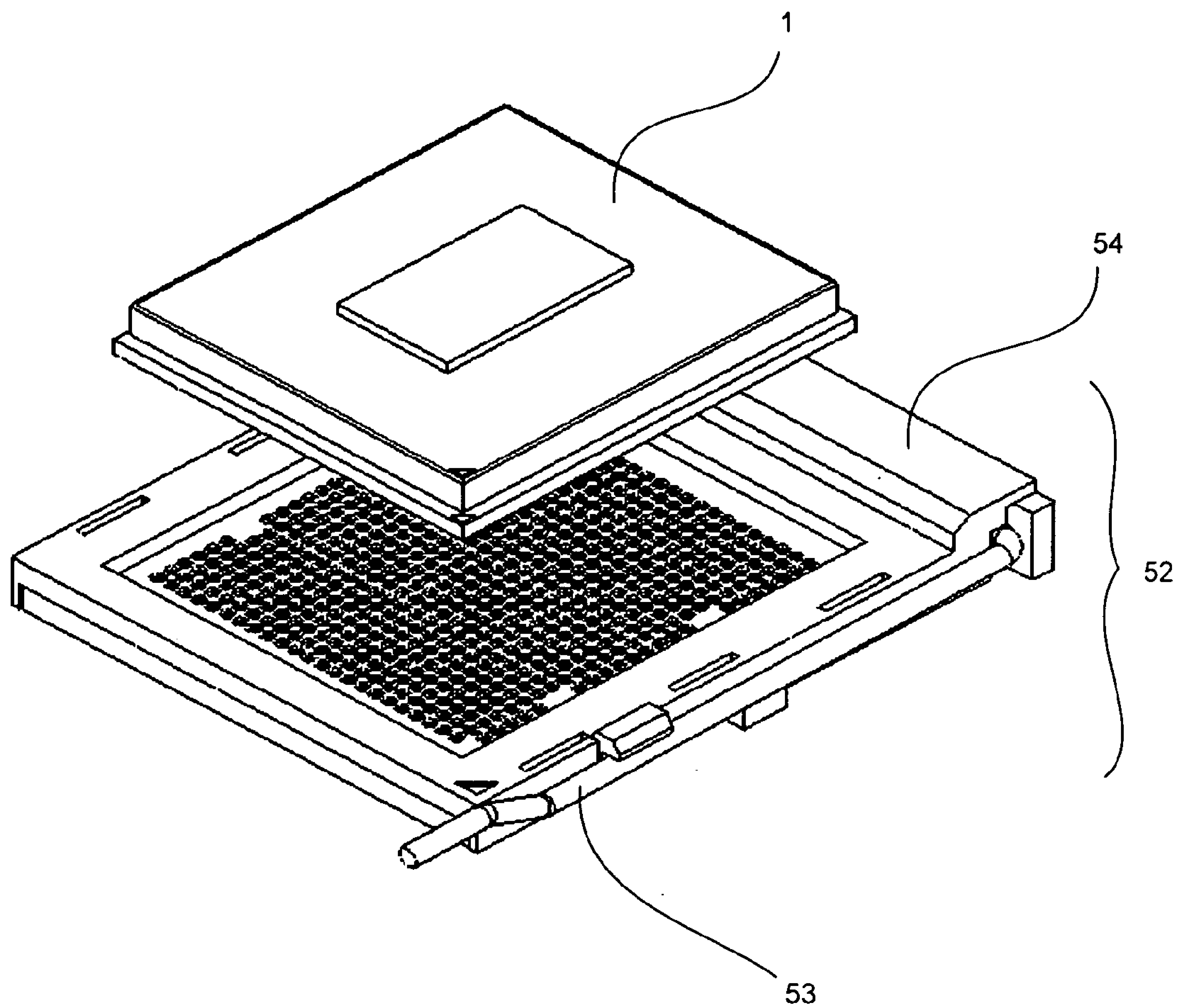


FIG. 9

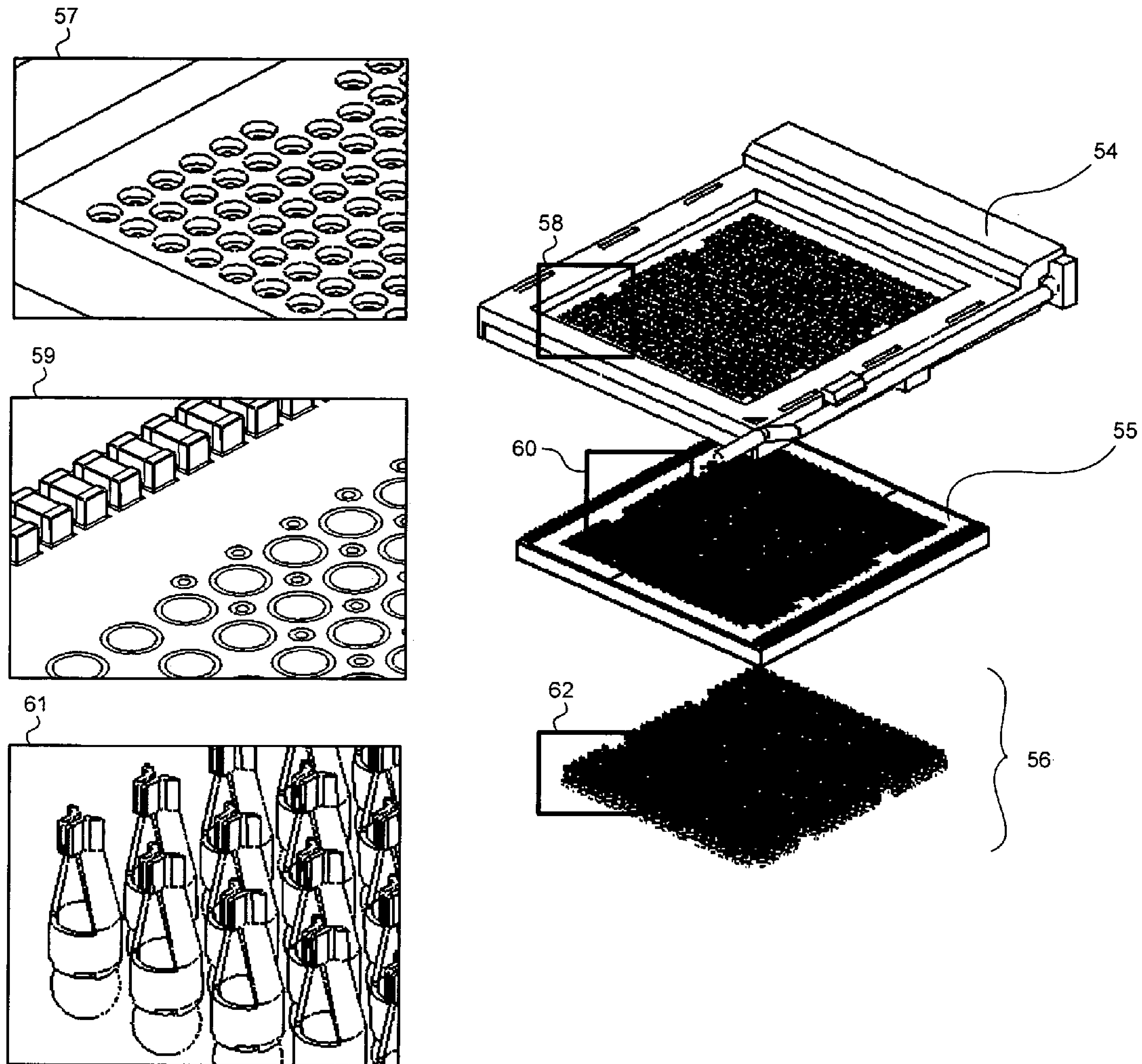


FIG. 10

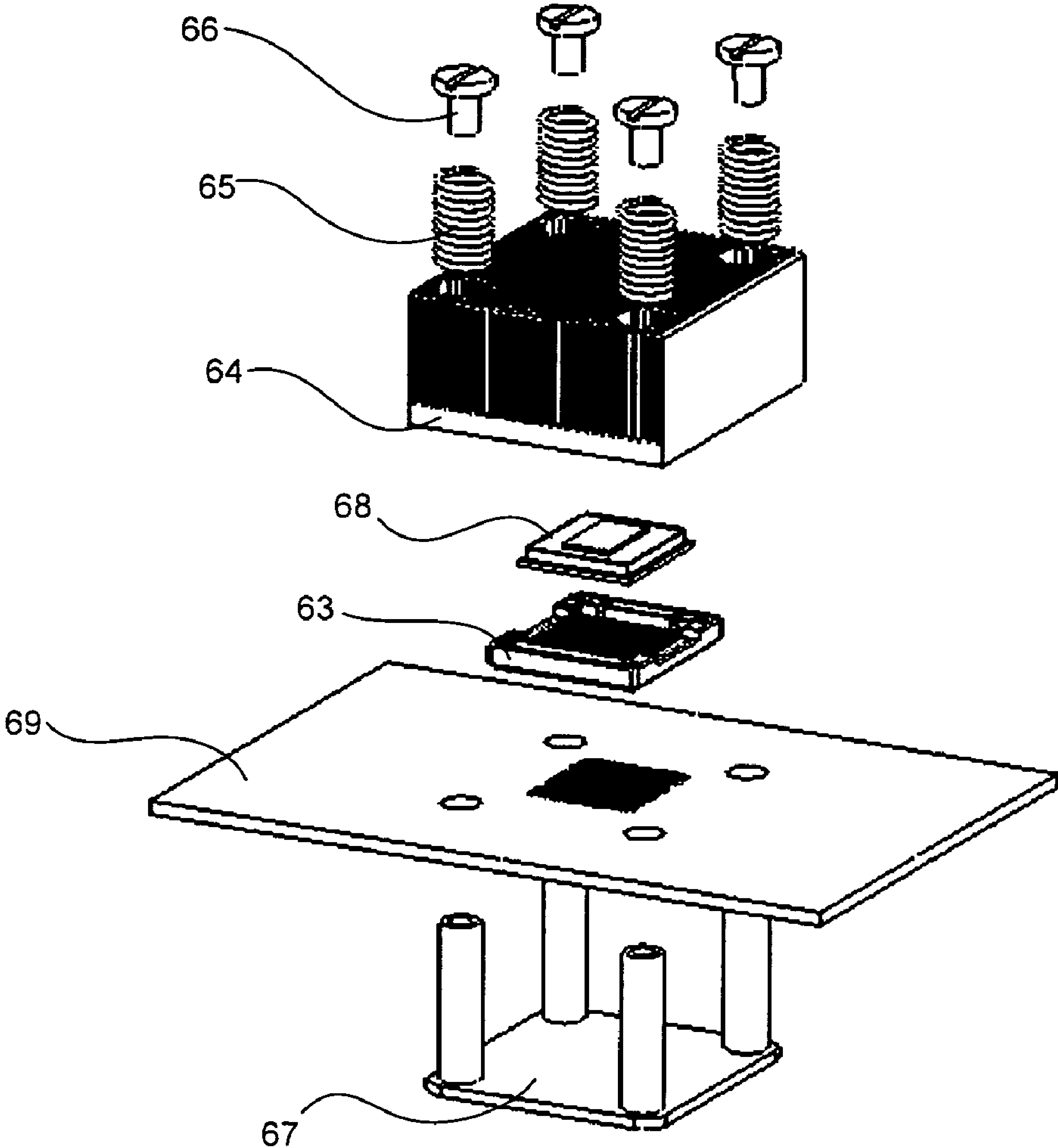


FIG. 11

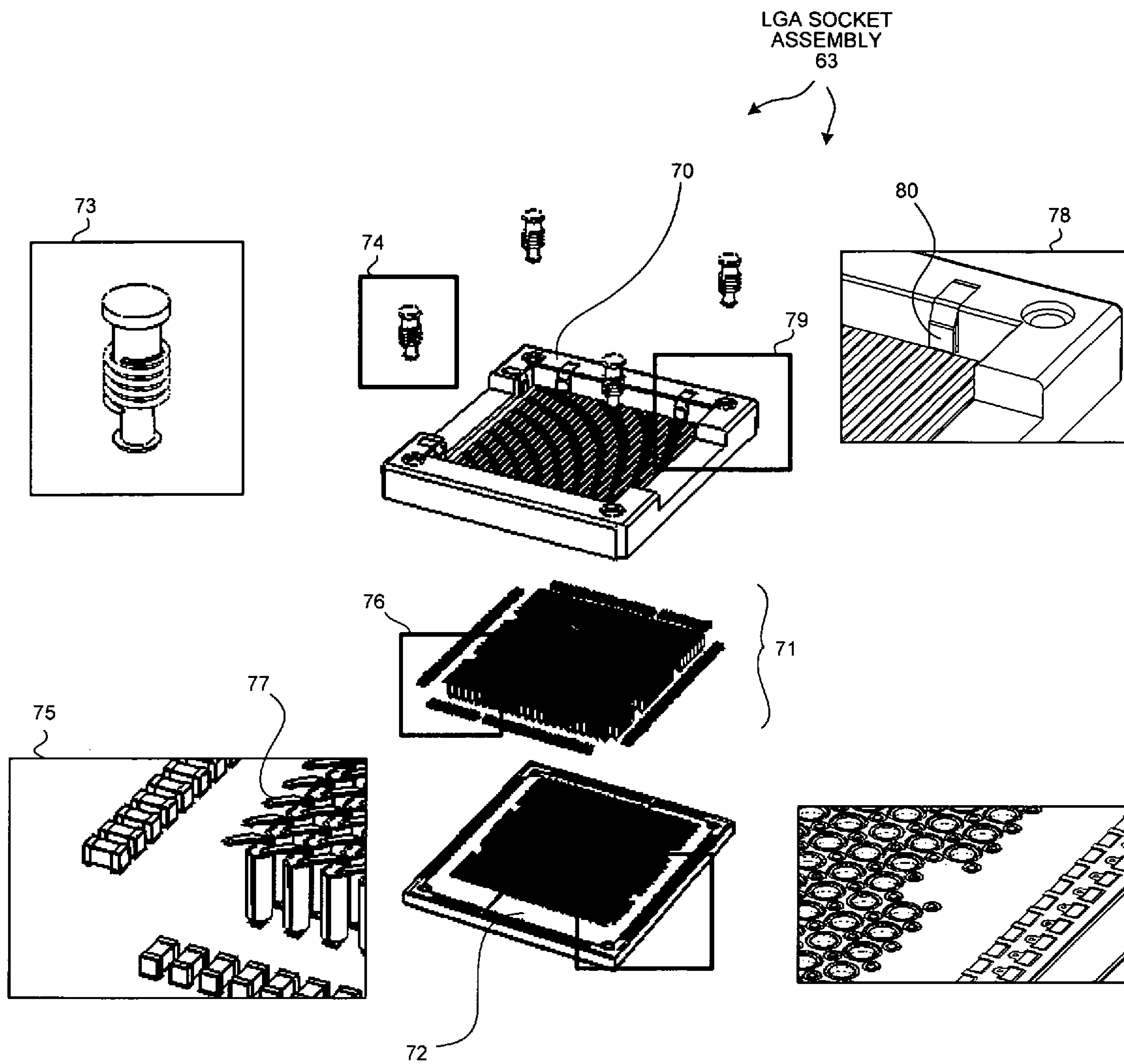


FIG. 12

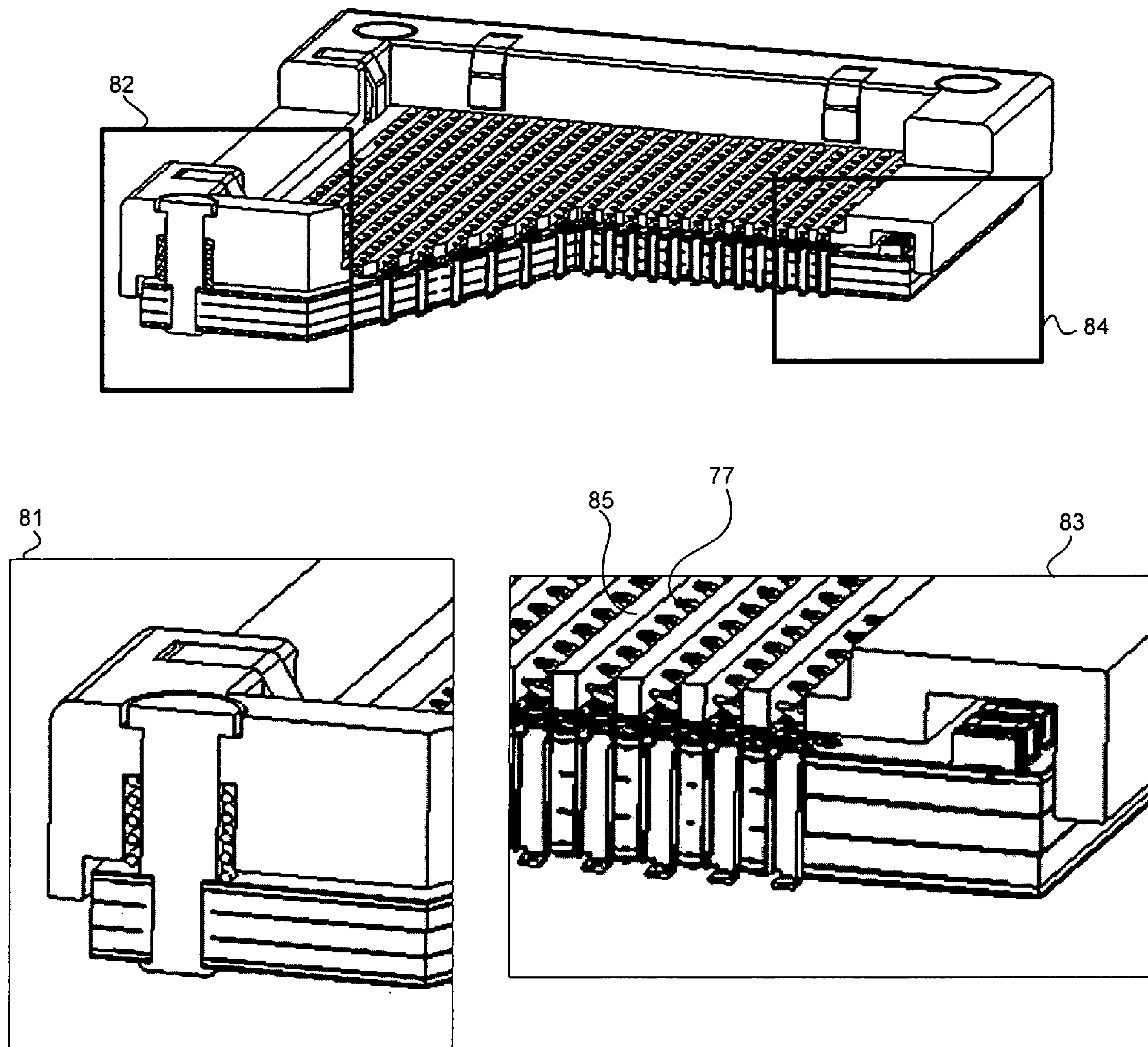


FIG. 13

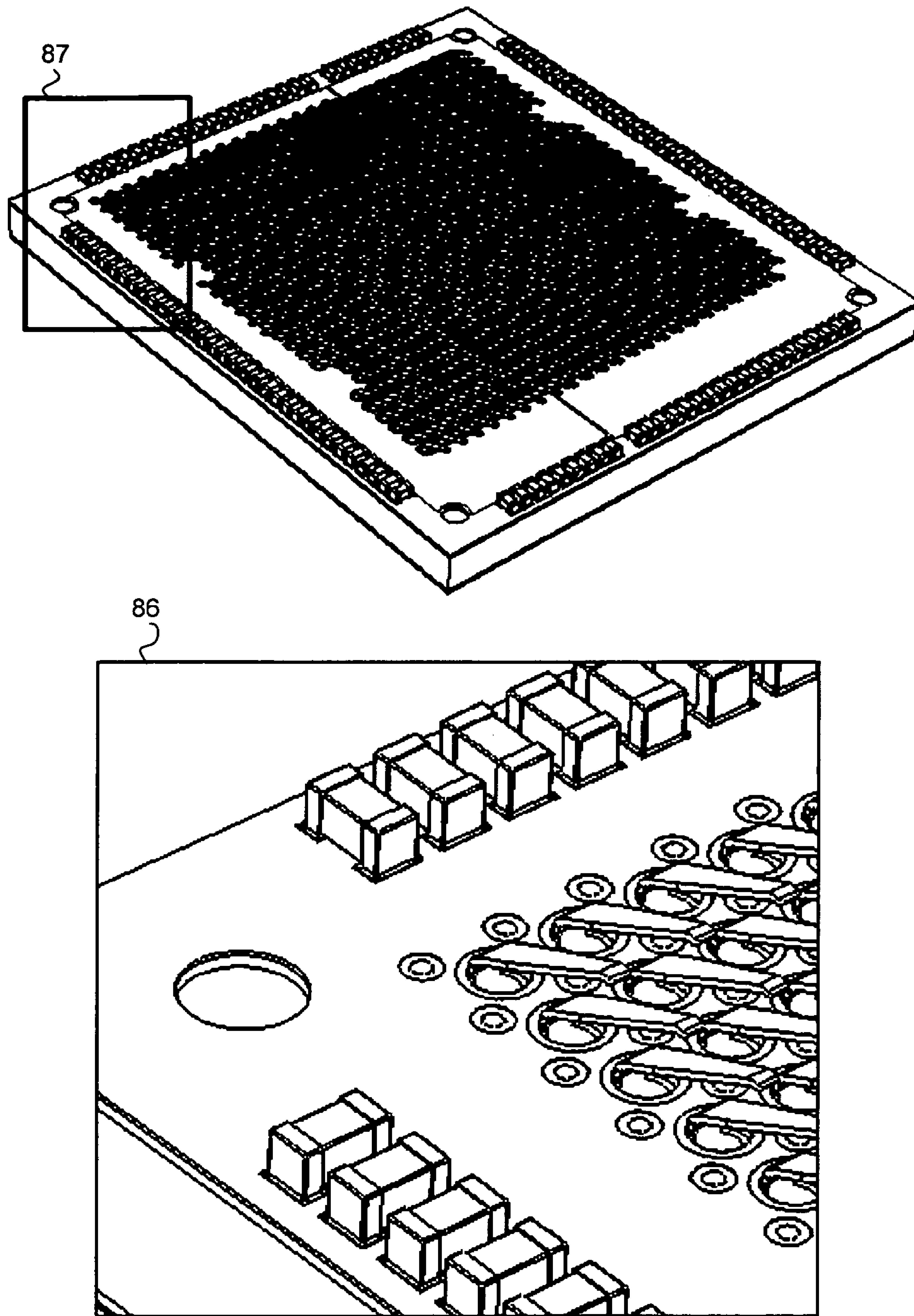
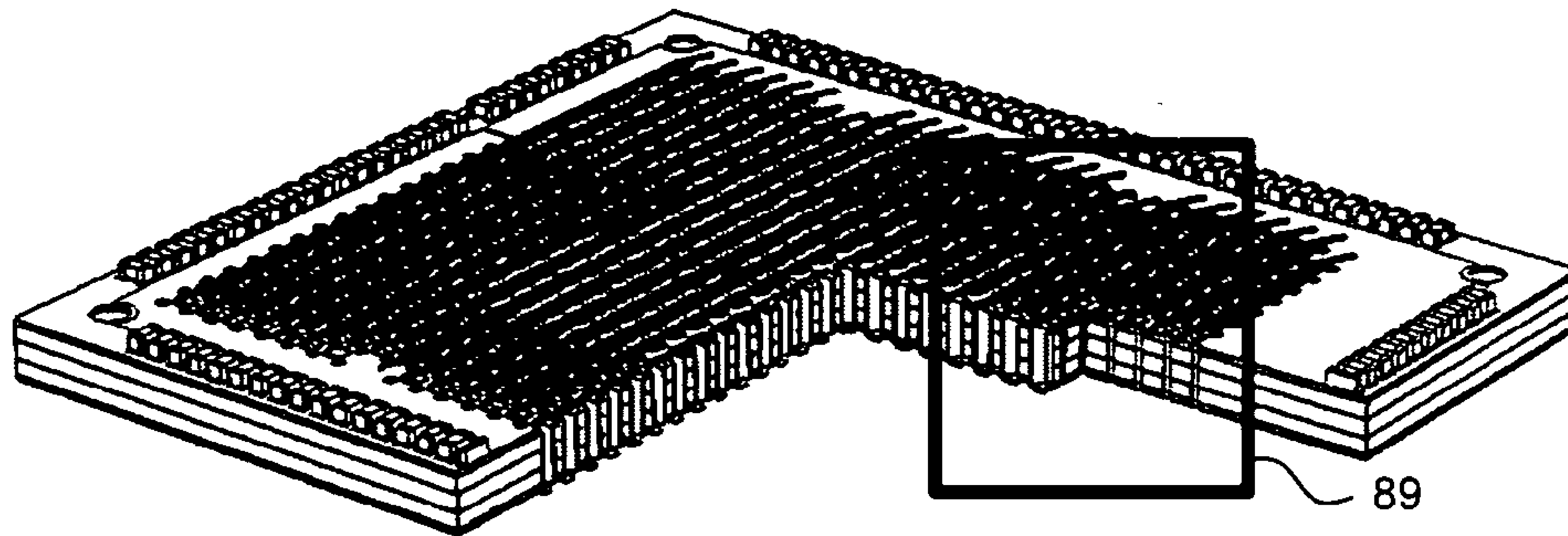


FIG. 14



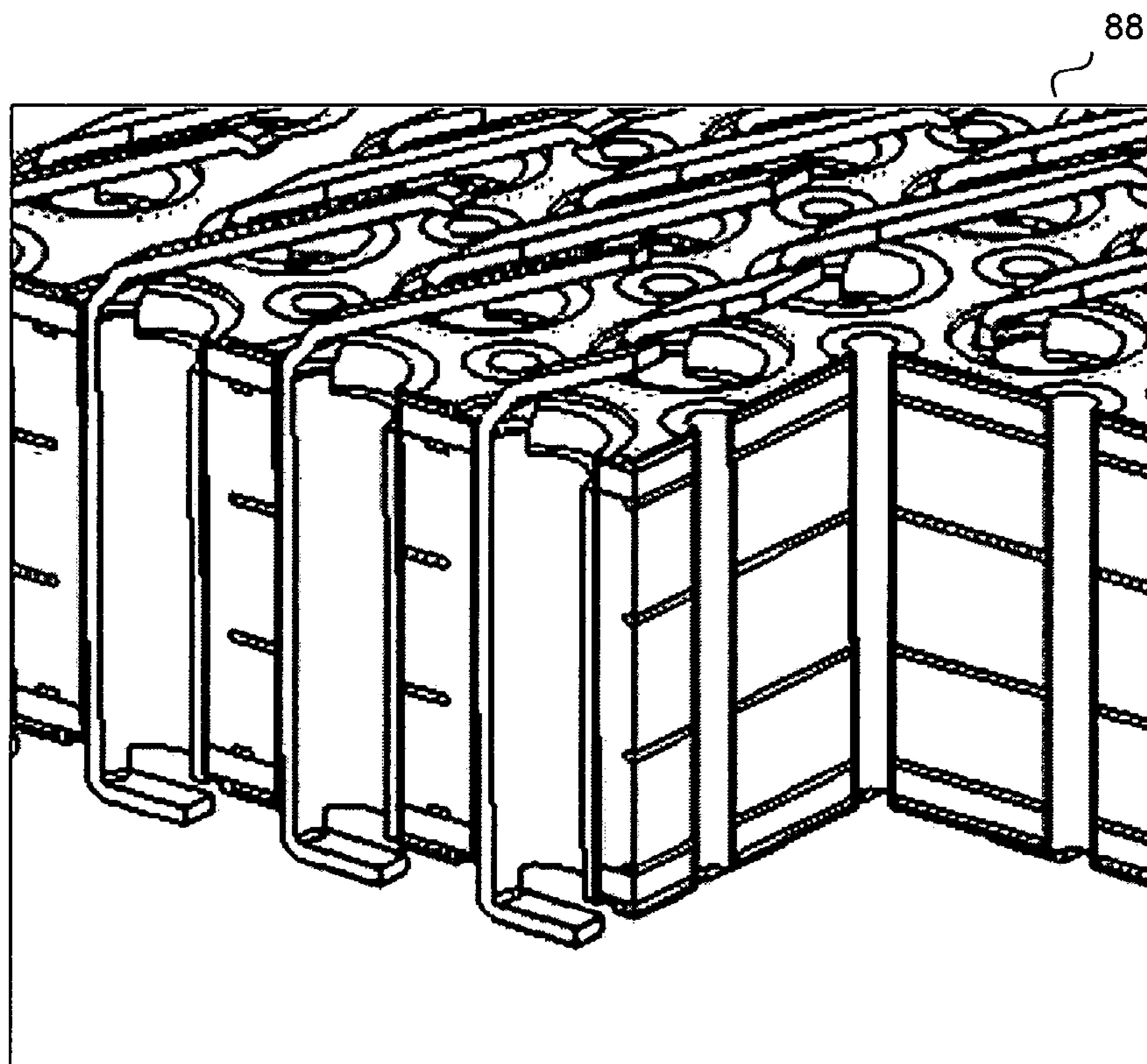


FIG. 15

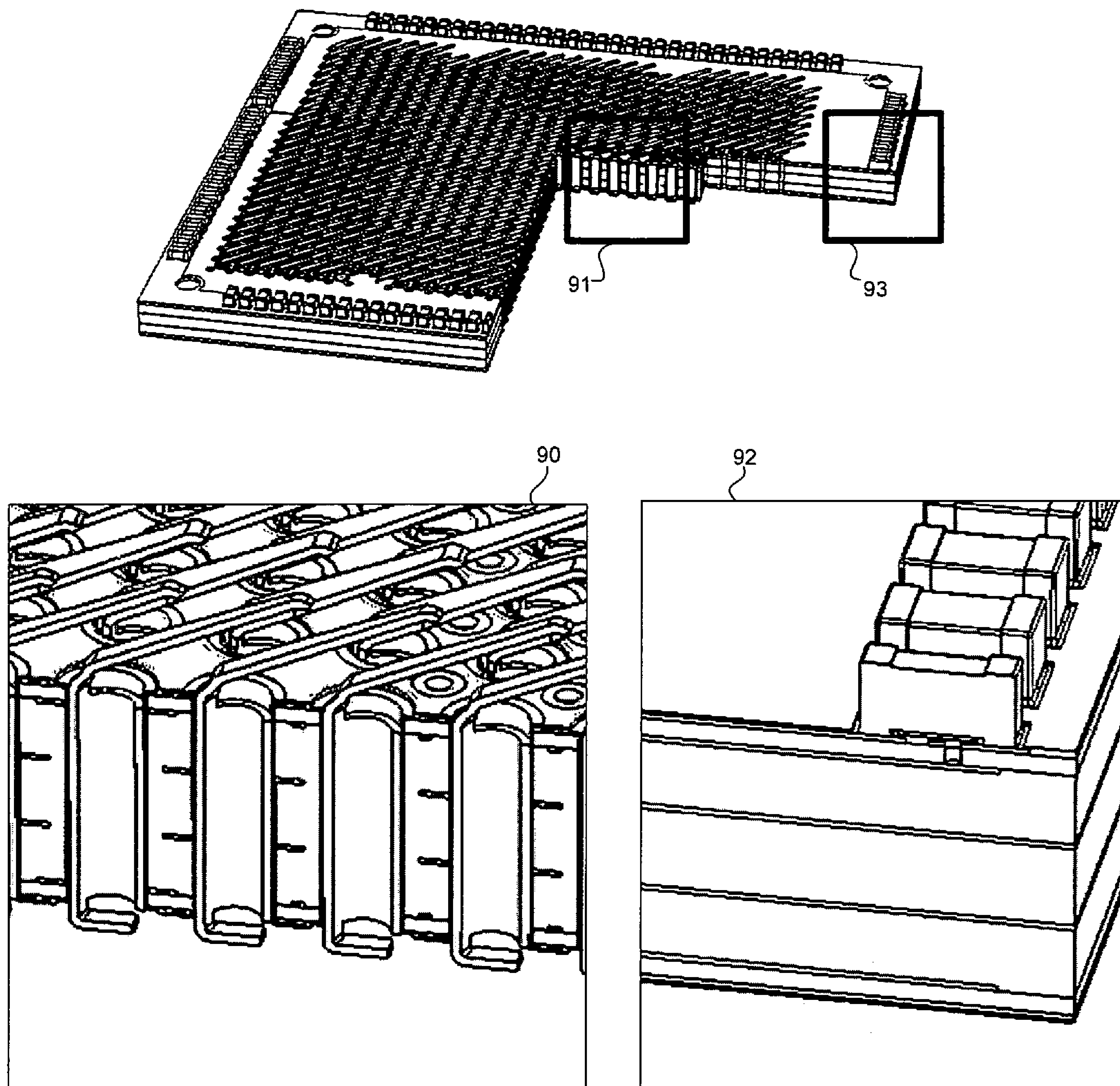


FIG. 16

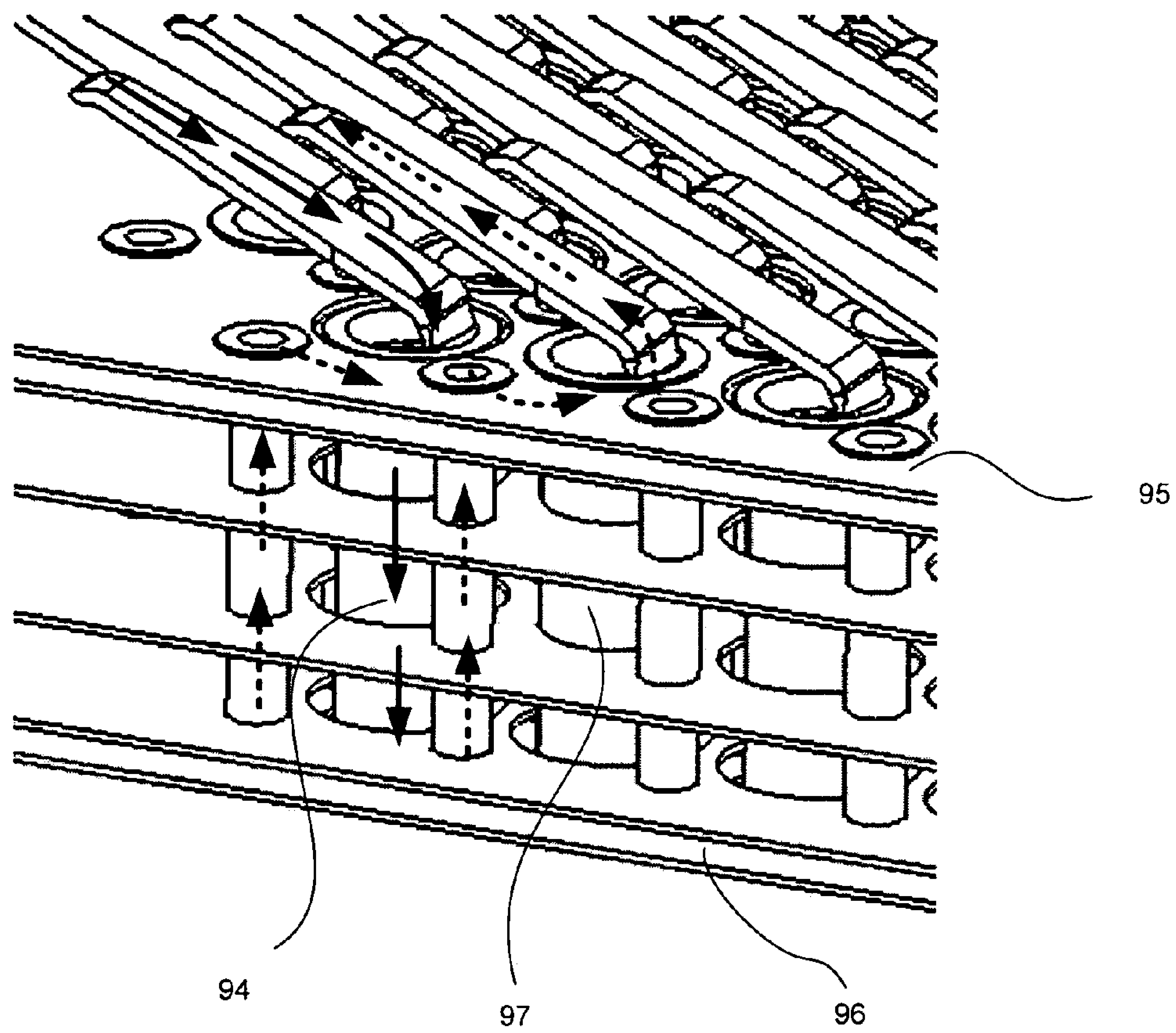


FIG. 17

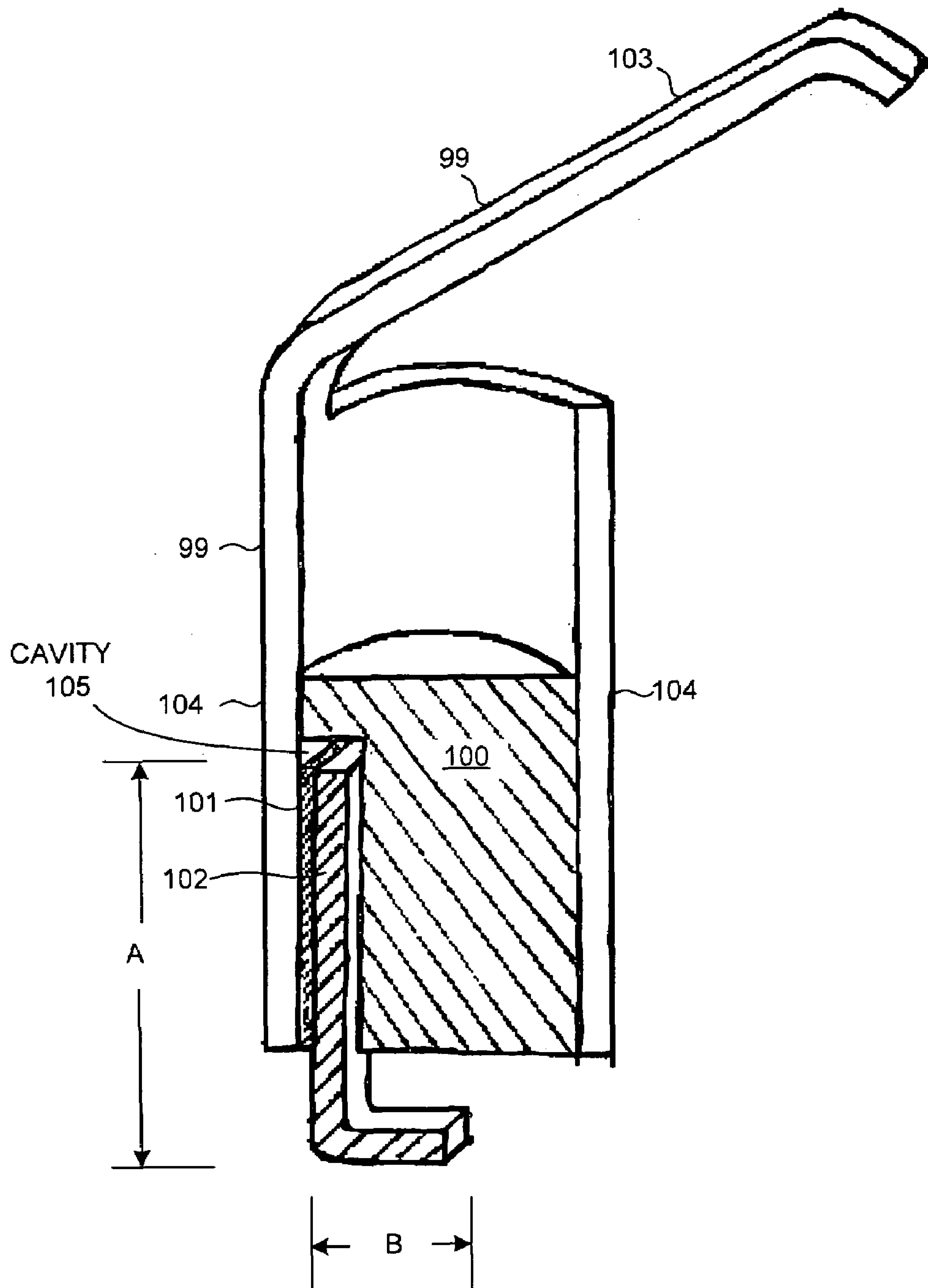
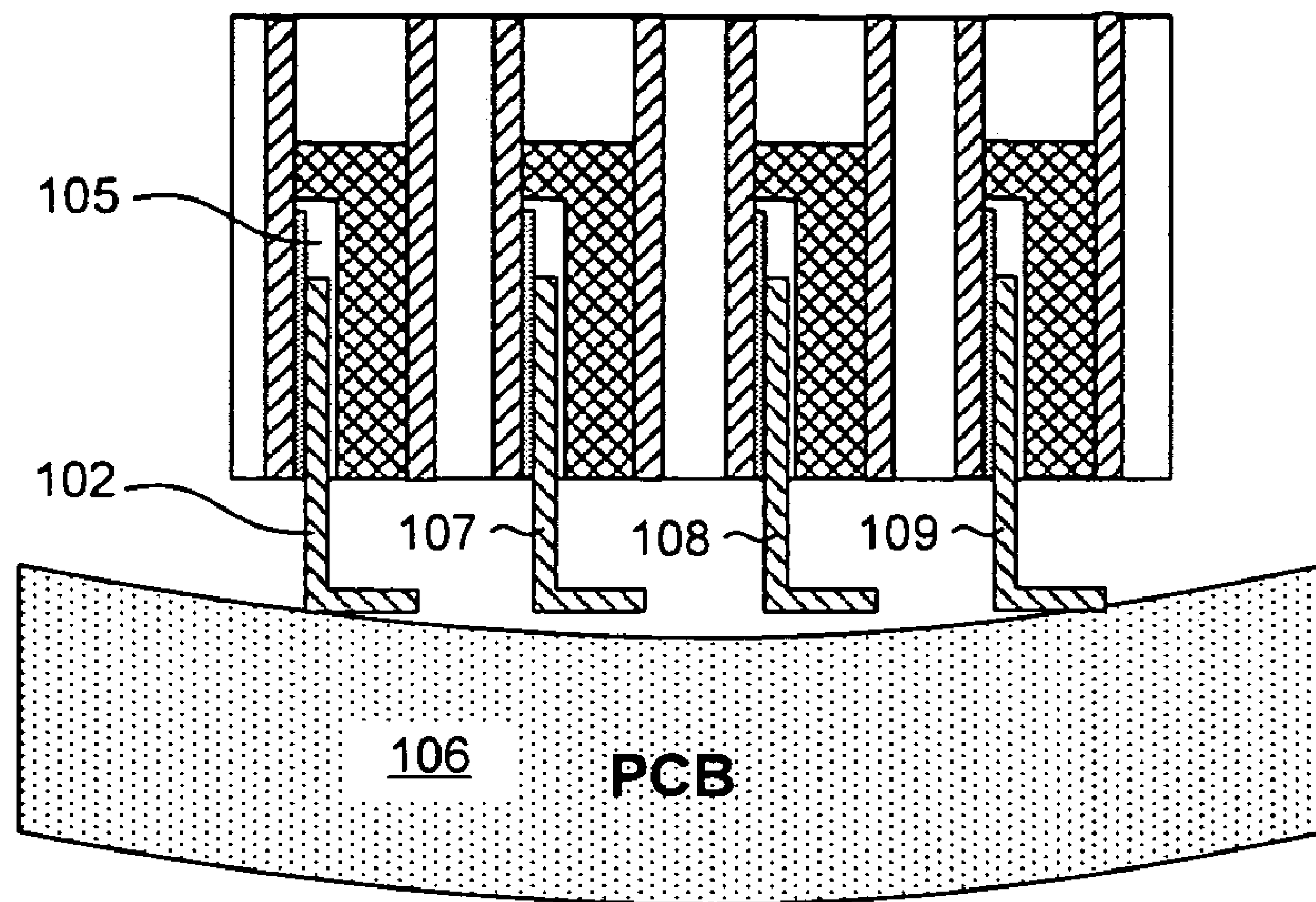
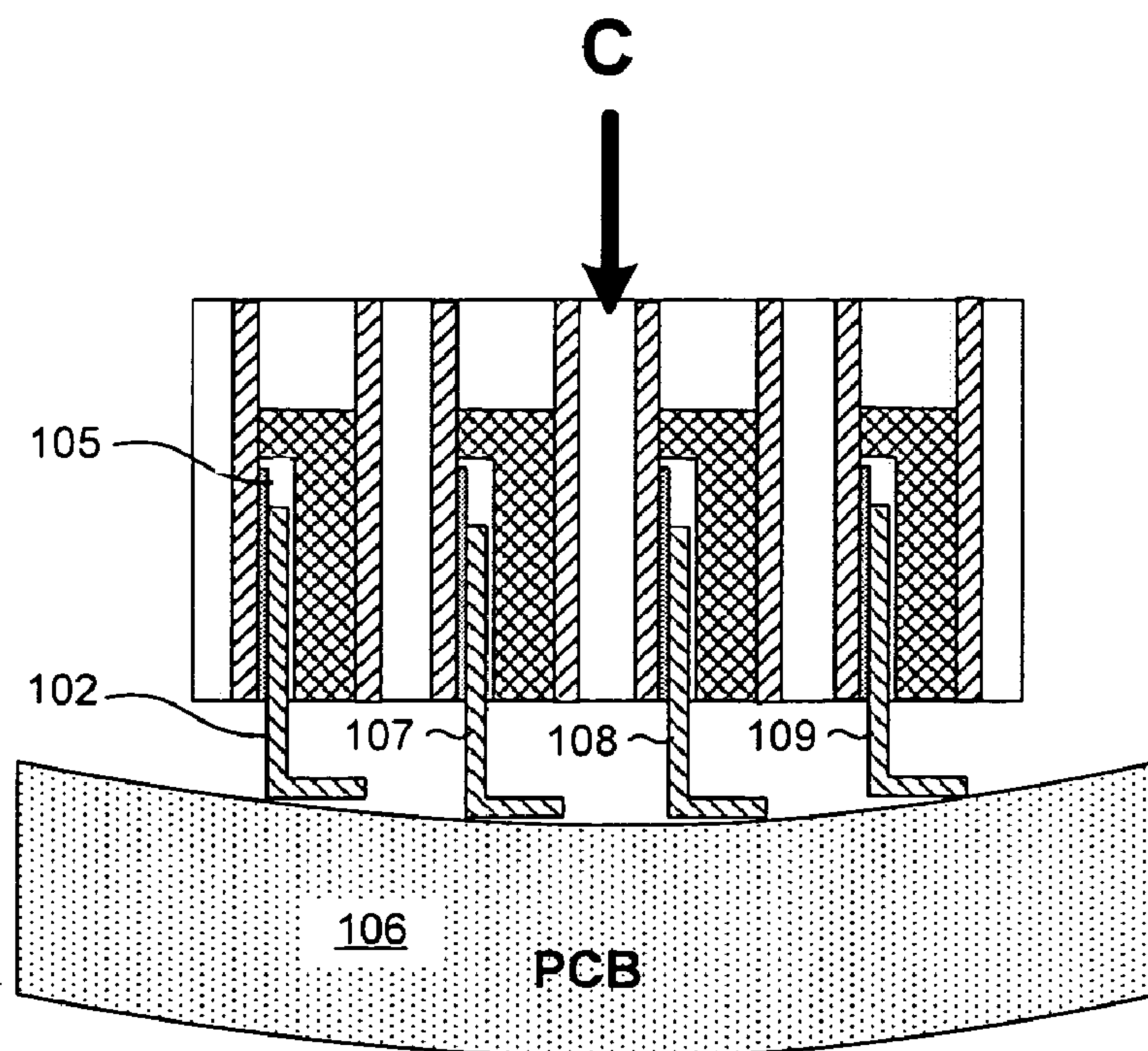


FIG. 18



BEFORE REFLOW SOLDERING

FIG. 19



AFTER REFLOW SOLDERING

FIG. 20

SOCKET HAVING PRINTED CIRCUIT BOARD BODY PORTION

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit under 35 U.S.C. §119 of provisional application Ser. No. 60/681,675, entitled "HIGH SPEED SOCKET", filed May 16, 2005. The subject matter of provisional application Ser. No. 60/681,675 is incorporated herein by reference.

SUMMARY INFORMATION

In one aspect, a high speed socket includes an insulative housing and a printed circuit board body portion. The PCB body portion includes a PCB and surface mount contacts. Each surface mount contact has a first end portion for making contact with an integrated circuit held in the socket and a second end portion for surface mounting to a printed circuit board. The socket's printed circuit board includes a matrix of AC grounded conductive columns (ACGCC). Each ACGCC extends from a first planar surface of the PCB to a second planar surface of the PCB. The printed circuit board also includes signal conductors. Each signal conductor is shielded by a plurality of surrounding ACGCCs. In another aspect, the socket includes capacitors that are surface mounted to the socket's PCB. In another aspect, the surface mount contacts include self-adjusting solder tails that adjust during reflow soldering to accommodate PCB warpage.

Other embodiments and advantages are described in the detailed description below. This summary does not purport to define the invention. The invention is defined by the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, where like numerals indicate like components, illustrate embodiments of the invention.

FIG. **1** is a perspective view of a non-ZIF (non zero insertion force) pin grid array (PGA) socket in accordance with a first novel aspect.

FIG. **2** is an exploded perspective view of the socket of FIG. **1**.

FIG. **3** is a top-down view of socket contacts in the socket body portion of the socket of FIG. **1**.

FIG. **4**A illustrates a pair of conductors in a conventional socket.

FIG. **4**B illustrates a pair of signal conductors in the novel socket. The signal conductor on the left is shielded by four surrounding AC grounded conductive columns (ACGCC) that extend parallel to the signal conductor.

FIG. **5** is an exploded view of various layers making up one embodiment of the PCB socket body portion of the socket of FIG. **1**.

FIG. **6** is an expanded perspective view of the socket body assembly of the socket of FIG. **1**.

FIG. **7**A is a sectional side view of the larger diameter plated through holes.

FIG. **7**B is a sectional side view of another portion of the socket body assembly. The plate through holes are for conducting power and ground potentials.

FIG. **8** is a cross-sectional view of a PGA package when it is inserted into the socket of FIG. **1**.

FIG. **9** is a perspective view of a ZIF (zero insertion force) pin grid array (PGA) socket in accordance with a second novel aspect.

FIG. **10** is an exploded view of the ZIF PGA socket of FIG. **9**.

FIG. **11** is an exploded perspective view of an LGA (land grid array) socket with LGA compression hardware in accordance with a third novel aspect.

FIG. **12** is an exploded view of the LGA socket of FIG. **11**.

FIG. **13** is a sectional perspective view of the LGA socket of FIG. **11**.

FIG. **14** is a perspective view of an assembly of the PCB socket body portion and LGA contacts and capacitors.

FIG. **15** is a cross-sectional diagram that shows the signal integrity portion of the LGA socket body assembly.

FIG. **16** is a cross-sectional diagram that shows the power integrity portion of the LGA socket body assembly.

FIG. **17** is an expanded view of the LGA socket body assembly of FIG. **11**.

FIG. **18** is a cross-sectional perspective view of an LGA contact and self-adjusting solder tail assembly in accordance with a fourth aspect.

FIGS. **19** and **20** illustrate an operation of the self-adjusting solder tail assemblies in the novel LGA socket of the fourth aspect.

DETAILED DESCRIPTION

FIG. **1** is a perspective view of a non-ZIF (non zero insertion force) pin grid array (PGA) socket in accordance with a first novel aspect. The pins of a PGA integrated circuit package **1** fit down into the socket **2**.

FIG. **2** is an exploded perspective view of socket **2** of FIG. **1**. The socket **2** includes an insulative housing portion **3**, a printed circuit board (PCB) socket body portion **4**, and an array of socket contacts **5**. Box **6** is an expanded view of box **7** of insulative housing portion **3**. A two-dimensional array of guide holes extends vertically through the insulative housing portion **3**. Box **8** is an expanded view of box **9** of socket body portion **4**. A two-dimensional array of larger diameter plated through holes **10** is provided. As seen in box **8**, four smaller diameter plated through holes **11** are disposed around each larger diameter through hole. A row of surface mount decoupling capacitors **12** is soldered to socket body portion **4**. The plates of the decoupling capacitors are coupled to ground and power planes within socket body **4**. Box **13** is an expanded view of box **14** of socket contact portion **5**. Socket contact **15** includes a cylindrically-shaped conductive portion **16**, and a pair of contact beams **17** and **18**. A solder ball **19** is soldered to the bottom of cylindrical portion **16**.

FIG. **3** is a top-down view of socket contacts **5** in place in socket body portion **4**. Box **20** is an expanded view of box **21** of the socket body/socket contact assembly.

FIG. **4**A illustrates a pair of conductors in a conventional socket. An aggressor signal present in the left conductor **22** induces small current in the right victim conductor **23**. This small current in the victim conductor **23** represents unwanted cross-talk.

FIG. **4**B illustrates a pair of signal conductors in the novel socket and four AC grounded conductive columns **24-27** (in the present example, the AC grounded conductive columns **24-27** are smaller diameter plated through holes). The arrows represent field lines. The presence of the four plated through holes **24-27** terminate field lines originating from the signal conductor **28** and help to prevent the aggressor signal in the left signal conductor **28** from inducing small currents (cross talk) in the right signal conductor **29**.

FIG. **5** is an exploded view of various layers making up one embodiment of the PCB socket body portion **4**.

FIG. **6** is an expanded perspective view of socket body assembly **4**. The dielectric material of the socket body is not shown so that the plated through hole conductors can be seen. Ground plane **30** is coupled to plate **31** of capacitor **32**. Power plane **33** is coupled to plate **34** of capacitor **32**.

FIG. **7**A is a sectional side view of the larger diameter plated through holes. The two left larger diameter through holes **35** and **36** are used to conduct signals between integrated circuit package **1** (not shown) and an underlying printed circuit board (not shown). The right larger diameter through hole **37** is used for grounding (return path) and couples a pin (not shown) on the integrated circuit package **1** to a ground conductor or ground plate of the underlying printed circuit board (not shown). The smaller diameter plated through holes **38-40** are connected by ground planes **41**A, **41**B and **42**A, **42**B to the larger diameter plated through hole **37** used for grounding.

FIG. **7**B is a sectional side view of another portion of the socket body assembly. The larger diameter power and ground plated through holes **43** and **44** are coupled to power and ground planes **45** and **46**, respectively. Surface mount discrete bypass capacitor **47** is soldered to the power and ground planes.

FIG. **8** is a cross-sectional view of the PGA package **1** when it is inserted into socket **2**. Box **48** is an expanded view of box **49**. A pin **50** of IC package **1** is shown inserted into socket contact **15**. A vertically-oriented hole **51** is provided in insulative housing portion **3** to allow heat from capacitor **12** to escape upward.

FIG. **9** is a perspective view of a ZIF (zero insertion force) pin grid array (PGA) socket **52** in accordance with a second novel aspect. The socket **52** includes a lever **53** and an insulative housing portion **54**.

FIG. **10** is an exploded view of the ZIF PGA socket **52**. The socket includes an insulative housing portion **54**, a printed circuit board (PCB) socket body portion **55**, and an array of socket contacts **56**. Box **57** is an expanded view of box **58** of insulative housing portion **54**. Box **59** is an expanded view of box **60** of socket body portion **55**. A two-dimensional array of larger diameter plated through holes is provided. Four smaller diameter plated through holes are disposed around each larger diameter through hole. A row of surface mount decoupling capacitors is soldered to the socket body portion. The plates of the decoupling capacitors are coupled to ground and power planes within socket body **55**. Box **61** is an expanded view of box **62** of socket contact portion **56**. The contact beam ends of these socket contact portions are shaped to receive pins from the side.

FIG. **11** is an exploded perspective view of a LGA (land grid array) socket **63** with LGA compression hardware in accordance with a third novel aspect. The hardware includes a heatsink **64**, springs **65**, screws **66**, and a bolster plate **67** having threaded columns. Socket **63** is soldered to printed circuit board **69**. IC package **68** has lands rather than pins. IC package **68** is placed in socket **63**, the threaded columns of the bolster plate are inserted through holes in the printed circuit board **69**, the heat sink **64** is placed on top, the springs **65** are inserted into accommodating holes in the heat sink **64**, and screws **66** and screwed down through the springs and heatsink to engage threads in the columns of the bolster plate **67**.

FIG. **12** is an exploded view of the LGA socket **63** of FIG. **11**. Socket **63** includes an insulative housing portion **70**, an array of LGA contacts and capacitors **71**, and a printed circuit board socket body portion **72**. The LGA contacts **71** are inserted from the top into larger diameter plated through holes in the socket body portion **72**. Box **73** is an expanded view of the guide pin and spring assembly of box **74**. There are four such guide pins and spring assemblies, one located at each corner of insulative housing **70**. The guide pin extends down and is press into an accommodating hole in printed circuit board socket body portion **72**. The springs allow the insulative housing portion **70** to move up and down with respect to the printed circuit board socket body portion **72**. Box **75** is an expanded view of box **76**. Rather than having pairs of contact beams, each LGA contact includes a contact spring **77**. When the IC package **68** is placed down on the socket, the contact springs **77** compress to make good electrical contact to contact pads on LGA package **68**. Box **78** is an expanded view of box **79**. A pusher **80** made of spring metal is provided in the cavity of insulative housing **70** to push IC package **68** to align it in position with respect to the LGA contacts.

FIG. **13** is a sectional perspective view of LGA socket **63** of FIG. **11**. Box **81** is an expanded view of box **82**. Box **83** is an expanded view of box **84**. A protective grill-shaped insulative structure **85** separates adjacent columns of LGA contacts **77**. When the IC package is initially placed on the socket, the insulative housing **70** is separated from socket body portion **72** by the four springs of the guide pin and spring assemblies. At this point, the grill structure **85** prevents the bottom of the IC package from touching any of the contact springs **77**. The IC package is then pressed down, depressing the springs, and thereby pressing down the insulative housing portion **70**. The only motion of the IC package is straight down with respect to the socket body **72**. As the IC package is pressed down farther, the pads on the bottom of the IC package make contact with the LGA contacts. The grill structure **85** helps prevent the fragile contact springs of the LGA contacts from being damaged.

FIG. **14** is a perspective view of an assembly of PCB socket body portion **72** and LGA contacts and capacitors **71**. Box **86** is an expanded view of box **87**. Each larger diameter plated through hole is surrounded by four grounded smaller diameter plated through holes.

FIG. **15** is a cross-sectional diagram that shows the signal integrity portion of the LGA socket body assembly. Box **88** is an expanded view of box **89**.

FIG. **16** is a cross-sectional diagram that shows the power integrity portion of the LGA socket body assembly. Box **90** is an expanded view of box **91**, and box **92** is an expanded view of box **93**.

FIG. **17** is an expanded view of the LGA socket body assembly. The dielectric material of the socket body portion is not shown so that the plated through holes can be seen. All of smaller diameter grounded plated through holes **94** are connected within the PCB socket body to: 1) a first ground plane **95** on the top of the printed circuit board socket body portion, 2) a second ground plane **96** on the bottom of the printed circuit board socket body portion, and 3) certain larger diameter plated through holes **97** (predetermined large diameter through holes that are used to connect to a ground pad on the IC package).

FIG. **18** is a cross-sectional perspective view of an LGA contact and self-adjusting solder tail assembly **98** in accordance with a fourth aspect. Assembly **98** is one of many such assemblies that are disposed in receiving holes in a PCB socket body portion of an LGA socket. The LGA socket can have a form as illustrated in FIG. **11**, except that the contacts are not as shown in FIGS. **13**, **15** and **16** but rather are as illustrated in FIG. **18**. The PCB socket body portion is a printed circuit board made of FR4 or other printed circuit board material and includes the layers of FIG. **5** and the matrix of grounded plated through holes (for example, see plated through holes **24-27** of FIG. **4**B).

Self-adjusting solder tail assembly **98** includes a contact **99**, an insulative plug **100**, a layer of solder **101**, and a surface-mount attachment structure called a solder tail **102**. Solder tail **102** is approximately 1.8 millimeters in dimension A, and 0.6 millimeters in dimension B. Contact **99** includes a contact spring portion **103** and a cylindrical body portion **104**. The contact is stamped from sheet metal. In one embodiment, all the contacts in the PCB socket body portion are of identical construction. To assemble the PCB socket body portion, the contact is formed to have the cylindrical body portion, but the contact spring portion is not yet bent. The solder tail is soldered to the inside of the cylindrical body portion. The plug is then inserted to be in the position illustrated in FIG. **18**. The resulting self-adjusting solder tail assembly **98** is then inserted into the receiving hole in the PCB socket body portion. The contact spring portion **103** is then bent to have the form illustrated in FIG. **18**.

FIGS. **19** and **20** illustrate an operation of the self-adjusting solder tail assemblies in the novel LGA socket of the fourth aspect. In a first step, solder paste is applied to the upper surface of a printed circuit board **106** to which the LGA socket is to be soldered. (The insulative housing portion of the LGA socket is not illustrated in FIG. **19** and only a narrow slice section involving four self-adjusting solder tail assemblies is illustrated.)

In a second step, the LGA socket is placed on printed circuit board **106** so that the bottoms of the solder tails make contact with the solder paste on the top of the PCB **106**. The structure to be assembled is as illustrated in FIG. **11** where LGA socket **63** is soldered to the upper surface of printed circuit board **69**. The upper surface of the printed circuit board may be non-planar due to printed circuit board warpage. Where the LGA socket is large (such as where the LGA socket has one thousand or more contacts and the LGA socket is two inches or more square), some of the solder tails may not be touching solder paste on the printed circuit board due to PCB warpage as illustrated in the exaggerated view of FIG. **19**.

In a third step, the structure of FIG. **19** is put through a reflow oven such that substantially all the solder holding the solder tail in the structure melts. Solder **101** melts, thereby freeing solder tail **102** to move vertically within a slide-guide cavity **105**. Slide-guide cavity **105** is a slit-shaped elongated volume formed between plug **100** and the cylindrical body portion **104**. The weight of the LGA socket (including insulative housing portion, the PCB socket body portion, and the contacts and capacitors) or another suitable force moves the LGA socket toward the PCB in direction C. The solder tails **102** and **109** that initially contact the PCB **106** are forced further into their respective cavities such that other solder tails **107** and **108** that previously did not contact PCB **106** now contact the PCB. The bottoms of all the solder tails **102**, **107**, **108** and **109** make contact with the PCB as illustrated in the simplified and exaggerated view of FIG. **20**. When the solder is in molten form, the solder tails are held in place in their respective cavities. At the end of the reflow soldering process, the socket and PCB structure cools such that the solder tails on the socket are soldered to the PCB.

Although certain novel aspects have been described in connection with certain specific embodiments for instructional purposes, the novel aspects are not limited thereto. For example, the self-adjusting solder tail assembly is illustrated here in use in an LGA socket, but it also sees use in connector structures including a back plane connector that is surface mounted to a PCB (for example a high speed right angle back plane connector or a high speed mezzanine connector). Although the self-adjusting solder tail assembly is illustrated here having a contact spring, the self-adjusting solder tail assembly may include a pair of contact beams for receiving a pin of a pin grid array (PGA) integrated circuit package. Accordingly, various modifications, adaptations, and combinations of various features of the described embodiments can be practiced without departing from the scope of the invention as set forth in the claims.

What is claimed is:

1. A socket for holding an integrated circuit package, the socket comprising:

an insulative housing, wherein a two-dimensional array of guide holes extends through the insulative housing; and

a printed circuit board socket body portion (PCB socket body portion) in contact with the insulative housing, the PCB socket body portion comprising:

a first printed circuit board that has a ground plane; and

a plurality of surface mount contacts, each of the surface mount contacts having a first portion for contacting the integrated circuit package and a second portion for surfacing mounting to a second printed circuit board.

2. The socket of claim **1**, wherein the first printed circuit board has a first planar surface and a second planar surface, the first printed circuit board including a plurality of AC grounded conductive columns (ACGCC), wherein each ACGCC extends through the first printed circuit board from a location proximate to the first planar surface to a location proximate to the second planar surface, wherein all the ACGCCs are electrically connected together and are electrically connected to the ground plane.

3. The socket of claim **2**, wherein the first printed circuit board further comprises a plurality of signal conductors, and wherein the first printed circuit board includes at least as many ACGCCs as signal conductors.

4. The socket of claim **1**, wherein the socket is a non zero insertion force pin grid array (PGA) socket.

5. The socket of claim **4**, wherein the first portion of each of the surface mount contacts includes a cylindrically-shaped conductive portion and a pair of contact beams, wherein the second portion of each of the surface mount contacts is a solder ball, and wherein the solder ball is soldered to the cylindrically-shaped conductive portion.

6. The socket of claim **3**, wherein each of the plurality of signal conductors is a larger diameter plated through hole, and wherein each of the plurality of ACGCCs is a smaller diameter plated through hole.

7. The socket of claim **6**, wherein four ACGCCs are disposed around each signal conductor.

8. The socket of claim **3**, wherein the first printed circuit board further comprises a power plane and a power conductor, and wherein the power conductor is coupled to the power plane.

9. The socket of claim **8**, further comprising:

a plurality of surface mount capacitors, wherein the capacitors are soldered to the ground plane and the power plane.

10. The socket of claim **9**, wherein the insulative housing includes a vertically-oriented hole to allow heat from the capacitors to escape upward.

11. A socket for holding an integrated circuit package, the socket comprising:

an insulative housing, wherein a two-dimensional array of guide holes extends through the insulative housing;

a plurality of cylindrically-shaped signal conductors disposed in a printed circuit board, wherein the printed circuit board is in contact with the insulative housing; and

means for preventing an aggressor signal in one of the signal conductors from inducing a cross-talk current in another signal conductor.

12. The socket of claim **11**, wherein each of the plurality of signal conductors is a larger diameter plated through hole, and wherein the means comprises a plurality of smaller diameter plated through holes.

13. The socket of claim **12**, wherein the printed circuit board includes at least as many smaller diameter plated through holes as signal conductors.

14. The socket of claim **12**, wherein the means further comprises a ground conductor of the larger diameter.

15. The socket of claim **12**, wherein the means further comprises a plurality of ground planes, wherein each of the plurality of ground planes is connected to the smaller diameter plated through holes.

16. A method comprising:

using a printed circuit board in a surface mount integrated circuit socket to conduct signals from a surface mount attachment structure of the socket to an integrated circuit held in the socket, wherein the socket includes an insulative housing in contact with the printed circuit board, and wherein a two-dimensional array of guide holes extends through the insulative housing.

17. The method of claim **16**, further comprising:

grounding a plurality of plated through holes of a smaller diameter, wherein the printed circuit board includes a plurality of signal conductors of a larger diameter and the plurality of plated through holes of the smaller diameter.

18. The method of claim **17**, wherein the printed circuit board includes a plurality of ground planes, wherein each ground plane is coupled to each of the plurality of plated through holes of the smaller diameter.

19. The socket of claim **2**, wherein each of the surface mount contacts is disposed between the first planar surface and the second planar surface.

20. The socket of claim **6**, wherein each of the guide holes is smaller than each of the larger diameter plated through holes.

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